

REMARKS

Claims 1 – 9, 17 and 29 – 46 are pending. Claims 29 – 37 are withdrawn from consideration.

Rejection of claims 1 – 4, 8 – 9, 17, and 38 – 39 under 35 U.S.C. §103 over Moss et al. in view of JP '431

At page 3 of the Office Action, claims 1 - 4, 8 - 9, 17, and 38 - 39 were rejected under 35 U.S.C. §103(a) as allegedly obvious in view of Moss et al. (U.S. Patent No. 3,532,543 to Nole et al.) (To be consistent with the Examiner's nomenclature in the Office Action, this reference will be referred to herein as "Moss et al.") and Japanese patent publication no. 47-28431 (hereinafter referred to as "JP '431"). The Examiner alleged that Moss et al. discloses a lithium-sulfur battery comprising a cathode configuration employing sulfur in combination with a porous carbon cloth structure and that the active cathode material may be either sulfur or a mixture of sulfur and a cathode composition including conductive carbon and a binder such as polyvinylchloride. The Examiner further alleged that Moss et al. describes that the preferred cathode configuration uses a porous carbon cloth structure because if the resulting structure is not porous enough, good electrolyte penetration is not obtained. The Examiner further alleged that Moss et al. describes that the active cathode ingredients may be applied to the carbon cloth support by spraying or dropping a coating dispersion including powdered sulfur, powdered carbon black and a methylene chloride-carbon disulfide carrier containing polyvinylchloride resin onto the carbon cloth support creating an electrode that is ready for use in the cell and that the porous carbon cloth structure can also serve as the current collector. The Examiner acknowledged that Moss et al. fails to expressly disclose the specific pore size of positive active material (i.e. the pore size of the porous carbon cloth structure). The Examiner alleged that JP '431 describes a sodium-sulfur secondary battery and describes that it is essential to use a porous conductor consisting of a material having a degree of porosity with pore diameters of 10 – 1000 μm as a cathode member to increase the conductivity of the cathode. The Examiner took the position that it would have been obvious to make the positive active material of Moss et al. by having the specific pore size of the JP '431 publication on the alleged grounds that the JP '431 publication reveals that in a battery system using sulfur it is essential to use a porous conductor consisting of a material having a degree of porosity with pore diameters of 10 – 1000 μm as a cathode member to increase the conductivity of the cathode. The Examiner alleged that such cathodes having the specific pore size are better conductors. The Examiner further alleged that since the prior art directly teaches a pore diameter of at least 10 – 15 μm , a prima-facie case of obviousness still exists. Moreover, the Examiner alleged that JP '431 and the present application share the same

field of endeavor as they both address and disclose alkali metal-sulfur based batteries and their related technologies. For the following reasons, this rejection is respectfully traversed and reconsideration is requested.

Independent claim 1 of the present application requires, among other limitations, a positive electrode having an electron-conductive path and an ion-conductive path and comprising a positive active material including an active sulfur in the form of solid phase elemental sulfur (S₈) and/or a polysulfide solution, and pores of an average size greater than or equal to substantially 5 μm and less than and including 15 μm having both electron-conductive and ion-conductive properties, wherein the active sulfur is disposed in the pores during an electrochemical reaction of the lithium-sulfur battery.

Moss et al., on the other hand, describes a lithium-sulfur battery wherein the cathode comprises a porous carbon cloth upon which an active cathode material of sulfur in a mixture of conductive carbon and a binder has been applied. As noted by the Examiner, Moss et al. does not describe pores of an average size greater than or equal to substantially 5 μm and less than and including 15 μm . Moreover, Moss, et al. does not describe that active sulfur is disposed in the pores during an electrochemical reaction of the lithium-sulfur battery since the active material in Moss et al. is attached to the carbon cloth support.

Moreover, JP '431 is non-analogous art that is not reasonably pertinent to the problems addressed in the present invention. In particular, JP '431 is specifically directed to the problem of providing conductivity to a molten sulfur electrode in a high temperature electrochemical cell, whereas the claim 1 of the present application requires that the active sulfur be in the form of solid phase elemental sulfur (S₈) and/or a polysulfide solution. Therefore, JP '431 does not relate to the same field of endeavor as the present invention and is not reasonably pertinent to the particular problems address in the present invention. Persons skilled in the art evaluating the teachings of JP '431 would interpret these teachings in the context of the problem of providing conductivity to molten sulfur and would understand that physical and electrical properties of molten sulfur would be significantly different from the physical and electrical properties of a solid phase elemental sulfur (S₈) and/or a polysulfide solution. JP '431 contains no teachings relevant to problems addressed in the present claims such as, for example, preventing the active material in the form of solid phase elemental sulfur (S₈) and/or a polysulfide solution from diffusing from active sites of the positive electrode. Therefore, a person skilled in the art would not look to JP '431 for guidance in modifying a positive electrode including solid phase elemental sulfur and would not be motivated to combine JP '431 with Moss et al.

Moreover, although JP '431 describes pore sizes of 10 – 1000 μm in its carbon cloth material, even if this teaching could be applied to the present invention, there is nothing in JP '431 that would guide a person skilled in the art from this extremely broad range to the specific,

narrow average pore size range of greater than or equal to substantially 5 μm and less than and including 15 μm . As noted in MPEP 2131.03(II.), where a broad range is disclosed in a reference, a narrower claimed range is not taught by the broad disclosure unless described with "sufficient specificity to be anticipation." It can be clearly seen in the English translation that the reference teaches away from the lower range of pore sizes. In particular, it is described in the paragraph at the top of the second page of the English translation that a small pore size inhibits substance travel of molten sulfur and sodium polysulfide and that therefore, a large pore diameter is preferable. Moreover, since JP '431 relates to an electrode using molten sulfur, there is no teaching or suggestion of the unexpected advantages of a material having an average pore size of greater than or equal to substantially 5 μm and less than and including 15 μm of preventing an active material in the form of solid phase elemental sulfur (S_8) and/or a polysulfide solution from diffusing from active sites of the positive electrode. Even more so, there is no teaching or suggestion of an average pore size of [greater than or equal to substantially 5 μm and] up to 10 μm as required by claim 2 or substantially 5 μm as required by claim 3.

For all of the above reasons, the rejection of claims 1 – 4, 8 - 9, 17, 38, and 39 over Moss et al. and JP '431 should be withdrawn.

Separate argument for patentability of claims 40 - 46

As a separate argument for the patentability of claims 40 – 46, these claims relate to a lithium-sulfur battery wherein the positive electrode is prepared by coating a composition including a conductive agent, a binder, and a plasticizer onto a current collector, removing the plasticizer from the composition coated on the current collector with an organic solvent to generate pores in the composition coated on the current collector; and injecting the polysulfide solution into the generated pores. The claims clearly define a physical product that is distinct from anything described in Moss et al or JP '431. In particular, a material having pores created by coating a conductive agent, binder and plasticizer onto a current collector and then removing the plasticizer would have different physical or morphological characteristics from a porous carbon cloth material or a porous material created by forming a coating composition with a solvent but without a plasticizer. Therefore, independent claim 40 defines a lithium-sulfur battery that is clearly distinguishable in physical attributes from anything described in Moss or JP '431.

Moreover, the Examiner is clearly in error in continuing to allege that the porosity of the positive electrode as claimed includes zero porosity or a pore-free material and that a plasticizer is not required. Claim 40 explicitly requires a plasticizer in the formation of the coated composition, and provides that the removal of the plasticizer creates pores in the coated composition. Moreover, claim 40 depends ultimately from claim 1, which clearly requires a non-zero average pore size. Thus, the allegation made by the Examiner that no removal of plasticizer

is required in the claim is clearly without basis. Therefore, claims 40 – 46 are allowable over Moss et al. and JP '431 for this additional reason.

Therefore, in view of the above amendments and arguments, the rejection of claims 1 - 4, 8-17, 38, and 39 over Moss et al. and JP '431 should be withdrawn and new claims 40 – 46 should also be allowed.

Rejection of claims 5 - 7 in view of Moss et al., JP '431, and Kovalev et al.

At page 9 of the Office Action, the Examiner rejected claims 5 - 7 under 35 U.S.C. §103 as allegedly obvious in view of Moss et al., JP '431, and Kovalev et al. (U.S. Patent No. 6,652,440). The Examiner applied Moss et al. and JP '431 as discussed above. The Examiner acknowledged that Moss et al. and JP '431 do not expressly disclose the specific particle size of the elemental sulfur. The Examiner alleged that Kovalev et al. teaches electroactive cathode materials for electrochemical cells wherein the cathode materials comprise sulfur-sulfur bonds such as elemental sulfur and that the cathode materials are useful in batteries employing alkali-metal anodes, in particular, lithium or lithium alloy anodes and that in one embodiment, the particle size of the elemental sulfur is from 0.01 to 100 microns. The Examiner took the position that it would have been obvious to one skilled in the art at the time the invention was made to use the specific particle size of the elemental sulfur of Kovalev et al. in the lithium-sulfur battery of Moss et al. and JP '431 on the alleged grounds that Kovalev et al. teaches that elemental sulfur having the claimed particle size is useful for making positive electrodes of lithium-sulfur batteries because this particular positive electrode material exhibits satisfactory specific capacity in combination with a lithium anode. For the following reasons, this rejection is respectfully traversed and reconsideration is requested.

As noted above, claim 4, from which claims 5 – 7 depend, would not have been obvious over Moss and JP '431. In particular, Moss et al. does not teach or suggest any positive active material having pores of an average size greater than or equal to substantially 5 μm and less than and including 15 μm . Moreover, Moss, et al. does not describe that active sulfur is disposed in the pores during an electrochemical reaction of the lithium-sulfur battery. JP '431 cannot be combined to supply the missing elements from the disclosure of Moss et al., since JP '431 is non-analogous art relating to a melted sulfur electrode and because there is no motivation for combining Moss et al. and JP '431.

Moreover, as discussed in Applicant's previous responses, the broad range of particle sizes described in Kovalev et al would not teach or suggest the narrower range of average particle size of claims 5 – 7. As noted in MPEP 2131.03(II.), where a broad range is disclosed in a reference, a narrower claimed range is not taught by the broad disclosure unless described

with "sufficient specificity." Clearly the broad description in Kovalev of sulfur particles of 0.01 microns to 100 microns would not teach or suggest sulfur particles of greater than 0 μm and up to 15 μm as required by claim 5, or greater than 0 μm and is up to 10 μm as required by claim 6 or greater than 0 μm and is up to 5 μm as required by claim 7.

Moreover, the mention in Kovalev et al. of sulfur particles of a size range of 0.01 microns to 100 microns would not have taught or suggested to a person skilled in the art to use sulfur particles of this size range in a positive active material prepared by a method comprising mixing an elemental sulfur (S_8) powder, a conductive agent, and a binder to provide a positive active material slurry; and coating the positive active material slurry on a current collector. Kovalev et al. does not describe any such use for its sulfur particles. Rather, it is described in Kovalev et al. that elemental sulfur particles are combined in a liquid medium with a non-conductive polymer and a precursor of a conductive polymer repeating unit and a polymerization initiator comprising an oxidant and that the mixture is reacted to form a grafted organic polymer. See, for example, col. 5, lines 6 – 20 and col. 12, lines 8 – 9 of Kovalev et al. The resulting polymer, as described, for example, at col. 7, lines 19 – 22 of Kovalev et al. is a polymer comprising conductive polymer segments and non-conductive polymer segments, wherein one or more of the conductive and non-conductive polymer segments are bonded to sulfide chains, particularly sulfide chains comprising one or more moieties selected from the group consisting of $-(\text{S}_m)-$, $-(\text{S}_m)^+$, and $(\text{S}_m)^{2-}$ where m is an integer from 3 to 200. It is this electroactive polymer having polysulfide chains that is used in the electrode described in Kovalev et al. Therefore, by the time that a positive electrode is formed according to Kovalev et al., the sulfur used to make the graft polymer is no longer in the form of sulfur particles, but rather in the form of sulfide chains. Accordingly, there is no description in Kovalev et al. of preparing a positive electrode by mixing an elemental sulfur (S_8) powder with a conductive agent and a binder to provide a positive active material slurry; and coating the positive active material slurry on a current collector.

Moreover, contrary to what is alleged by the Examiner, there is no motivation to combine the alleged teachings of Kovalev et al. with respect to sulfur particle size with alleged teachings of Moss et al. and JP '431. As noted above, Kovalev et al. does not teach or suggest preparing a positive electrode by mixing an elemental sulfur (S_8) powder with a conductive agent and a binder to provide a positive active material slurry; and coating the positive active material slurry on a current collector, since by the time the cathode electrode is formed in Kovalev et al., the sulfur powder has been converted into sulfide chains of the form $-(\text{S}_m)-$, $-(\text{S}_m)^+$, and $(\text{S}_m)^{2-}$, where m is an integer from 3 to 200. There is nothing in Kovalev et al. that specifically relates the particle size of its starting material for forming a grafted organic polymer to any characteristic or advantage of the positive electrode formed with the grafted organic polymer. Kovalev et al.

contains no disclosure that would have lead or motivated a person skilled in the art to directly use elemental sulfur having the described particle sizes in the material of Moss et al.

Therefore, the rejection of claims 5 – 7 over Moss et al., JP '431, and Kovalev et al. should be withdrawn.

CONCLUSION:

There being no further outstanding objections or rejections, it is submitted that the application is in condition for allowance. An early action to that effect is courteously solicited.

Finally, if there are any formal matters remaining after this response, the Examiner is requested to telephone the undersigned to attend to these matters.

If there are any additional fees associated with filing of this Amendment, please charge the same to our Deposit Account No. 503333.

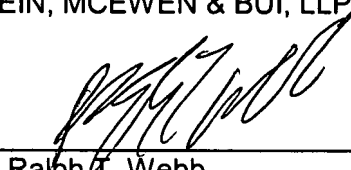
Respectfully submitted,

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May 11, 2007

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